# Biological Expedition to the Rain-Forest of Sabah in 1976



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Tsuneaki KOBAYASHI and Mitsuru HOTTA

The present article is a summarizing account of the biological research in Sabah, East Malaysia, which had been carried out from August to October in 1976.

There has been long time since the first biological researches took place in Sabah, but there still remain many unsolved problems behind their brilliant nature which may eventually contribute greatly to the biological science. SCLATER's oriental region which may be roughly defined as Asia, hold nearly half of the world's human population. Man has been active here for over million years. He has changed the face of the tropical rain-forest, the flora, altered its climate and greatly affected its wild life. The nature of Borneo is still of unusual biological interest. Here the rich flora and fauna of tropical rain-forest are less disturbed by human activities than in any other part of comparable Southeast Asian country. Her broad continuous rain-forest and rising high mountains provide the most favorable environment for both plant and animal species. It has been clearly said that complexity of a tropical ecosystem in this area permits two interpretations as follows. The first one, the genetical flank of a biological community, certain processes of genetical variation are active in this area, namely the mutation rate or the number of generation is speeded up and have been resulted to make numerous course of diversity on the phylogeny. According to the second, the ecological one, the rain-forest of Malaysia offers the most favourable environment for life on the earth. The equatorial climate, with constant high humidity and high temperature, combined with heavy year round rain-fall and strong sunlight may provides suitable conditions for maximun growth of life that is living among them. The tropical rain-forest of Malaysia favours the accumulation of species and continues coexistance of an exceptionally high number of life form which has been produced by the general speciation process.

In Borneo alone, there are some ten thousands species of plant form, a single hectare of jungle may include a hundred or more different tree species and neighbouring hectare will add almost the same number of close species to the list. The tropical rain-forest is constructed fundamentally by these tree complex, and be modified by the association of other form of life. In general, these trees and associated life have been made up to the complex, three-dimensional, matrix-like community. This matrix-like structure must be taken into account even if one is considering for single member of the tropical fauna and flora. The different part of the forest offers quite different habitat to the plant and animal. This is the reason why life in the rain-forest are described in horizontal strata; terrestrial forms ranging over the forest floor, arboreal creatures living high in the can-

1) Contribution from the "Kyoto University Biological Expedition to the Malesian Tropical Rain-Forest", No. 1.

opy and a wide range of intermediate types arrange from the ground to the tree crown.

The present research is the primary attempt in the course of resolving the complex problem lying in the speciation or divergence which has been found in the tropical rain-forest, and also aims to find out new general rules resulted from the new analytical method for the taxonomic and ecological data. In principle, there is no evidence that the speciation in the tropical zone differs from that of the other zone. Moreover, there are some advantages in studying evolutionary trend of tropical rain-forests, that is, the accelerated generation of species is always followed by a variety of diversing process which might eventually result in the formation of species groups. Every sample in above case which might be picked up from an arbitarary ecosystem, always shows various degrees of diversing process. That gives us many clues to resolve the problem lied behind the evolution.

The ecosystem of the tropical rain-forest in the Southeast Asia is a characteristic deligation of a biological community on the earth, which involves important keys for resolving the complexity.

"Biological Expedition to the Malesian Tropical Rain-forest" have been organized in accordance with the above mentioned purpose and was sent to the jungle of Sabah, East Malaysia, with the schedule showed in the Table 2.

The first step of faunal and floral investigations had already been conducted until middle of this century. The attention may now turn to the other facet of the problem which appeared in certain group of animals and plants, just as D. Dwight Davis (1962) stated, "testing and synthesizing the taxonomic hypotheses" or exploring the ecological relationship lies between them.

## Acknowledgments

This expedition was fully managed by the "Overseas Scientific Research Grant" delivered from the Ministery of Education of Japan. The College of Liberal Arts, Osaka University is acknowledged with our gratitude for granting leaves of their valued colleague for participation in this party.

Generous co-operation was extended to us by the State Government of Sabah, the Japanese Counsul and Vice-Counsul at Kota Kinabalu, Sandakan Liaison Office of Marubeni Corporation and their officials, Representative Office of Nisho-Iwai Company Ltd. and officials, The Mamut Copper Mine and their co-operatives. Author's sincere thanks are due to them.

During our field-work in Sabah, much indispensable assistance was provided by the people of Sabah. Among them, we are deeply obliged to the Forest Department of Sabah, particularly to Messes. MARTYN, the Directer, P. F. COCKBURN, the Botanist of Research Center, and J. Aban GIBOT, the Assistant Researcher of the Center who led the asisstant team being sent from the Center. Our grateful thanks also due to the Muziam Sabah (Sabah Museum) and his Officials, especially to Mr. Micheal Chong On PING, the Curator, and Mr. Chung En FU, the Administrative Officer, they had provided us transportations to survey areas from Kota Kinabalu and had granted to

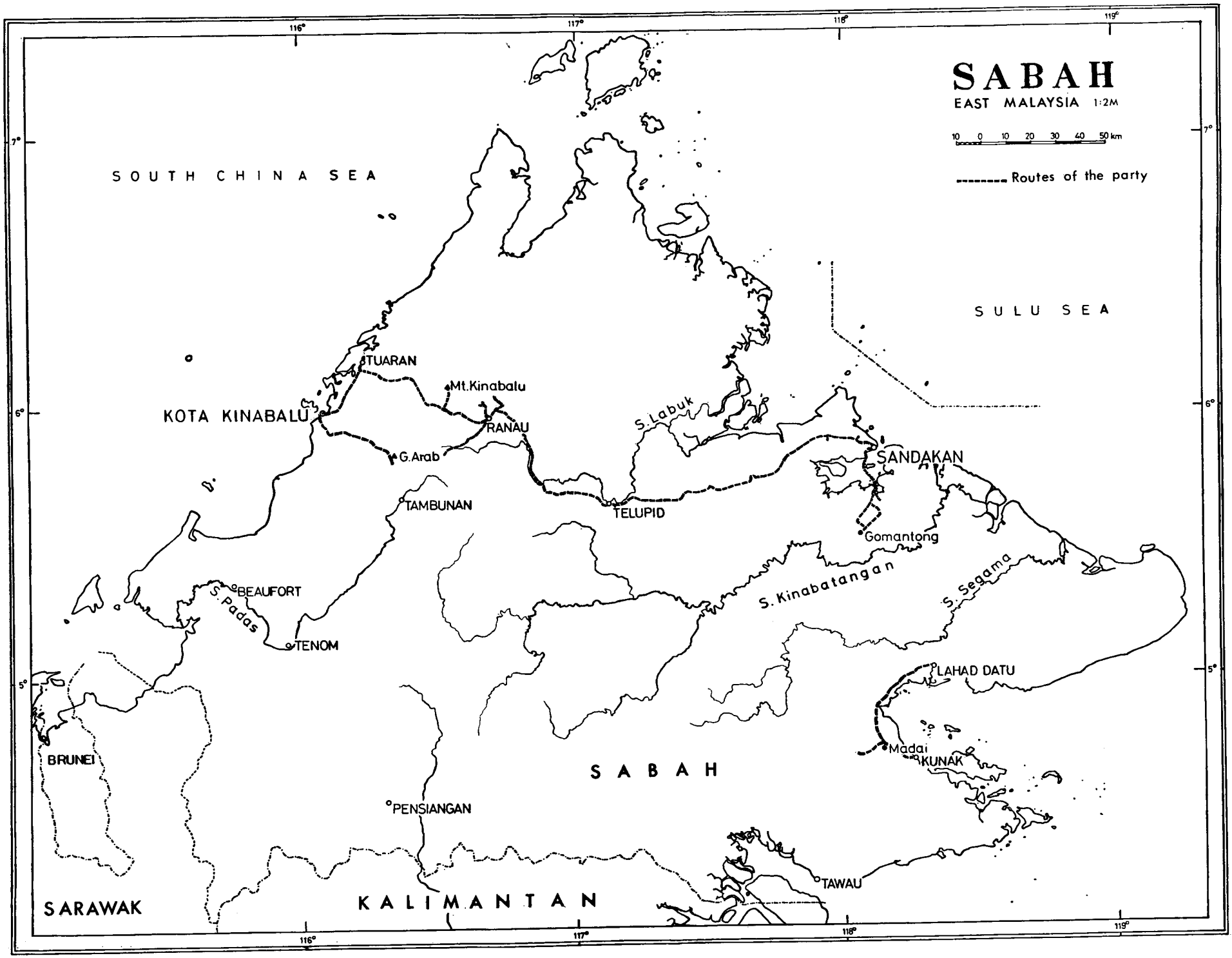


Fig. 1. Land map of Sabah, showing the rout of the survey and localities where collections were made.

share their trained assistant, Mr. Chen Mann LEE, for entire field trips.

The Forest Research Center in Sepilok, the Muziam Sabah, the Forest Department of Sarawak, the Sarawak Museum, Singapore University Museum and Singapore Botanic Garden had kindly granted permission to study materials under their care.

## Organization

After the World War II, the Kyoto University and his persons concerned have sent expedition parties to the Borneo Island in several installment (HOTTA, 1965). The main purpose of these parties had been concerned with floral investigations. They had brought back general collections of wildlife to their institutions from arbitrary localities. These totaled about ten thousands in numbers of specimens belonging to Spermatophyta and Pteriodophyta, have been stored in the herbarium of Botanical Institute, Faculty of Science, Kyoto University. A small amount of specimens, being consisted mainly of vertebrates procured by the same manner, were sent and stored in several suitable institutions.

On the base of these collections and their reports, the present expedition was planned and organized by Dr. Riozo YOSII, Professor of Biology at Kyoto University.[1] Its personnel including Dr. Michio TAMURA, Associate Professor of Biology at Osaka University, and the authors of the present article, shared their contributions for the project as follows.

Organizer and Leader;

Dr. Riozo YOSII (Entomologist)
Soil insects.

Personnel;

Dr. Tsuneaki KOBAYASHI (Mammalogist, Associate Professor of Biology)
Small mammals and its ectoparasitic arthropods.
Dr. Mitsuru HOTTA (Botanist, Associate Professor of Biology)
Angiosperm plants.
Dr. Michio TAMURA (Botanist, Associate Professor of Biology)
Angiosperm plants.

The fundamental plan of a field-work in Sabah were made up according to the forest type which appear arbitrarily throughout the island.

## Environments

### Sabah and her nature (Fig. 1)

The Sabah, strictly the former British colony of North Borneo, is located on the northern most of the Borneo Island. the State is divided into a larger eastern part and a smaller western part by the continuous mountain ridges running from the northern-most of the island to the southwestern direction. The most conspicuous topography of the western part is the steep and lofty massif of Mt. Kinabalu, which rises from the

[1] Present status; Emeritus Professor of Kyoto University.

seashore to the height of 4,101 m at the northern end of the Crocker Range. The mountain rises well above the dense forest zone, as he is faccinating every one's heart. The dome appeared above the forest line is a foliating granite rock with a dozen major peaks, some of them are crowned with the name of early explorers or the king of Britain. Peaks of Low's (the highest one), King Edward, King George, St. John's and Victoria have lofting summit of over 4,000 m and they give a jagged appearance to the rocky dome of the mountain (Frontispiece).

The eastern part of the state, there appears an open field being consist of a series of river basins which is seperated by a long stretch of rugged hills on the mountain foot and extends towords the east-coast residency through the immence jungle of the tropical ever-green forest. There is a large interior Pinosok Plateau lying between southeastern face of Mt. Kinabalu and Sungai Bambangan (Bambangan River). The western part, west of the Crocker Range, is consist of a narrow coastal plain of about 40 km in width, extending along the west coast.

On the eastern part, the native peoples live in very thin population and rather dispersed. The aborigines of western coast live on the hill-side and their population is much more denser.

The tropical rain-forest originally covered far the greater part of Sabah. This original cover of the forest has been disturbed by human activities. In the west coast, the forest has been seriously damaged by the aborigines who cut and burned a large tract of forests on mountain slope (Plate II-A, B). Here the original forest has been replaced by the secondary forest with entirely different predominant elements. On the eastern part, the original forest is also going to disappear by heavy commerical logging pressure (Plate II-E, F). The logging works are going to extend towards the interior part and reached to the upper basin of the Labuk and Kinabatangan River in 1976.

**Climate;** The general feature of the climatic condition in Sabah shows typically wet tropical type. The seasonal change of climatic factors are not obvious and the monthly variation of temperature is also very little (Table 1). The monthly means of temperature observed on lowland localities, Sandakan and Kota Kinabalu, were 26.9°C and 27.5°C respectively, with an average value of about 2°C in a total variation of a monthly mean. On Kota Kinabalu, actual extremes of the yearly value in maximum and minimum are about 33°C and 20°C, respectively. On the higher mountain area as on Mt. Kinabalu, there appears a mountaineous climate which is very similar to the temperate zone with an exceptional characteristic of the mean value that is extremely invariable throughout the year. It was happened on Kambaronghoh station (ca. 2,100 m alt.) that the daily mean of the temperature showed less than 15°C.

Annual rainfall varies between 1,500 and 4,000 mm according to the localities. Brunei Bay area (Labuan) and the northeastern coastal residency (Sandakan) shows the heaviest annual rainfall, while in the interior land (Tenom, Keningau and Tambunan) and the south-eastern corner of Sabah (Tawau—Lahad Datu area) shows the

Table 1. Summarized meteological features of Sabah.

A. Monthly variation of temperature (°C).

| | | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kota Kinabalu | Maximum | 29.4 | 29.7 | 30.3 | 30.6 | 31.2 | 30.7 | 31.0 | 30.6 | 30.7 | 30.4 | 30.6 | 29.7 | 30.4 |
| (1961)* | Minimum | 22.2 | 22.8 | 23.4 | 23.9 | 24.1 | 23.6 | 23.0 | 23.3 | 23.2 | 23.0 | 23.4 | 23.2 | 23.3 |
| | Midvalue in month | 25.8 | 26.3 | 26.9 | 27.3 | 27.7 | 27.2 | 27.0 | 27.0 | 27.0 | 26.7 | 27.7 | 26.5 | 26.9 |
| Labuan | Mean (1916–1954)**** | 27.2 | 26.7 | 27.5 | 28.1 | 28.1 | 27.8 | 28.1 | 27.8 | 27.5 | 27.5 | 27.5 | 27.2 | 27.5 |
| Sandakan | Maximum | 28.6 | 29.5 | 30.5 | 31.6 | 31.7 | 31.6 | 32.2 | 31.9 | 31.8 | 30.9 | 30.0 | 29.1 | 30.8 |
| (1961)* | Minimum | 22.9 | 23.3 | 23.0 | 23.1 | 23.0 | 22.5 | 21.9 | 22.2 | 21.8 | 21.7 | 22.2 | 22.9 | 22.5 |
| | Midvalue in month | 25.8 | 26.4 | 26.8 | 28.4 | 28.4 | 27.1 | 27.1 | 27.1 | 26.8 | 26.3 | 26.1 | 26.0 | 26.7 |
| | Mean (1879–1941)**** | 26.4 | 26.7 | 27.2 | 28.1 | 27.8 | 27.8 | 27.8 | 27.8 | 27.8 | 27.5 | 27.2 | 26.7 | 27.5 |

B. Monthly variation of rainfall (mm).

| | | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kota Kinabalu | Maximum | 711 | 76 | 254 | 254 | 305 | 381 | 457 | 457 | 660 | 457 | 483 | 483 | |
| (1956–1964)** | Minimum | 0 | 0 | 25 | 25 | 102 | 203 | 127 | 102 | 178 | 178 | 152 | 25 | |
| | Average | 127 | 51 | 76 | 152 | 229 | 305 | 279 | 254 | 330 | 356 | 305 | 279 | 2743 |
| Labuan | Average (1916–1954)**** | 112 | 117 | 150 | 297 | 345 | 351 | 318 | 297 | 417 | 465 | 419 | 284 | 3571 |
| Sandakan | Highest year (1914) | 561 | 610 | 235 | 233 | 240 | 281 | 270 | 146 | 450 | 290 | 579 | 507 | |
| (46 years' data; | Lowest year (1938) | 203 | 4 | 32 | 43 | 144 | 178 | 113 | 112 | 221 | 176 | 110 | 147 | |
| 1896–1957)*** | Average | 465 | 276 | 208 | 127 | 154 | 187 | 192 | 216 | 242 | 273 | 345 | 464 | 3148 |

*.....North Borneo Annual Report, 1961. Government Printing Dept., Jesselton (=Kota Kinabalu).

**.....Chatfield, G. A., 1972. Sabah, a general geography. pp. 204. Eastern Univ. Press, Sandakan BHD.

***.....Fox, J. E. D., 1973. Kabili-Sepilok Forest Reserve. Sabah Forest Record 9: pp. 102.

****.....Tokyo Tenmondai (Tokyo Astronomical Observatory) ed. 1970. Rikanenpyo. Maruzen, Tokyo.

lightest annual rainfall.

The northeast monsoon brings a maximum precipitation to the east coast (Sandakan area), while the southwest monsoon (from May to August) and the interperiod of monsoon brings a maximum precipitation to the west coast (Labuan and Kota Kinabalu). The seasonal pattern of rainfall in the west shows approximately reverse phase of that on the east coast.

On the tropical zone, the duration of consecutive days without rain is far more important factors to keep the rain-forest ecosystem than total rainfalls, because the forest decicate so rapidly in the absence of rain as to destroy themselves. In this report, we have no suitable data to prove this problem.

**Geography;** COLLENETTE (1964) had reported the geography of the Mt. Kinabalu and surrounding highlands as follows;

They "are built of strongly folded segimentary strata enclosing bodies of igneous rocks." He classified the constracting rocks into four broad units.

(a) Sedimentary rocks; These are oldest of the rocks and from the lower slopes flanking the mountain.
(b) Ultrabasic and basic rocks; These appear intrusive into the sedimentary rocks.
(c) Granodiorite, which is intrusive into sedimentary and ultrabasic rocks, and forms the central part, or core, of the Kinabalu massif.
(5) Rock debris and alluvium partly fills some of the valleys and has considerably modified the topography on the south side of the mountain.

**Limestone cave**—The limestone in Sabah occurs in isolated outcrops, forming hills and cliffs, sometimes embeded in the mountain. These outcrops and embeded masses have developed numerous limestone caves with various scale throughout the country. The most of them, are difficult to access but there are several famous caves in the east coast jungle. The cave of this kind is true to type, that it has long been the house of the small swiftlet (*Collocaria*), whose nests have been exported to China as a material of "Birds' Nest Soup" for centuries. These caves are communally owned by native groups occupying nearby villeges. The Gomantong Cave is the special case in this state, the owner of this famous cave is the Forest Department of Sabah himself, and the officer being dispatched by the Forest Department have stationed and purchase all of the collections being gathered by nest collecters. The collection and sale of the nest is strictly controlled on there.

Limestone caves, as mentioned above, have grown abundantly on the limestone hills and outcrops. An interior of a cave is principally the dark place devoided of direct sun-light and they supported no green plants, the producer of the ecosystem. So the cave is holding its abundant animal life not to its attractiveness as feeding place but because of its aptitude of a comparatively safe shelter for enormous number of bats and swiftlets (Plate VII-A, B, C, E). These animals spread out far and wide into the

surrounding forest to feed, and return to roost and breed in there. The other animals dwelling in the cave, are usually invertebrates and they depend directly or indirectly on the bat and swiftlet, living off them either as parasites or as a part of food chain supported by the wet, brown pile of a guano, rotting corporals or insect debris that they drops.

Cave swiftlets build up cup-shaped nests attaching to the side and domes of the rock "cathedral". A large colony of several million birds may roost and nest in one cave. Their nest was built by their own secreted saliva and dried up to harden it. This hardened cup is cleaned in the hot water to remove dusts and dirty feathers. Then, the softened, clean cup of saliva becomes surely the materials for it, the priceless "Soup".

The bats and swiftlets are usually acompanied by their attendant parasites, including blood sucking bugs, ticks and flies. Crickets, millipeds, spiders and daddy-long-legs (Opiliones) are found on the wall, inside the crevice of a limestone rock. Cock-roaches (*Pycnoscelus*) are also found in enormous number on or in the thick pile of guano accumulated on the cave floor. This archaic insect might be an exploiter of the guano (Plate VII-D). Also feeding on the guano, a little sand-cased caterpillar of a moth (*Tinea*), beetles and springtails (Collembola) are found in numerous numbers.

Today, some of these caves are still regarded with awe as a spiritual place. Many arborigines neighbouring the limestone hill, use the cave for burial grounds or places of worship.

**Rain-Forest (Plate I and III, IV, V)**—Structure of the rain-forest in Sabah is a complex three dimensional matrix within which the associated animal life appears. For correct understanding of the animal life in a tropical rain-forest, one must be consider this three-dimensional structure. This complexity makes the life of animals to the specialized one. Not only flying birds, bats, insects, which are well fit to live and feed in the upper layer of the forest, but fascinating array of squirrels, monkeys, civets, snakes and lizards, snails and even frogs are able to live in the canopy quite independent of the forest floor. The mode of life changes their original form and function in multifarious manner. Monkeys have strong, prehensile hands and feet to grasp supporting branches at the canopy. Their strong hind legs make a wide leap to the neighbouring tree by the strong kick-off. In reptiles, many of the species have changed to the leaper or the gliding form. The famous flying lizard (*Draco*) develops membraneous wings being framed with prolonged ribs on each side. Amphibians, as in the flying (or tree) frog (*Rhacophorus*), have developed sucking disc and expanding webs on or between their digits. Flying lemur (*Cynocephalus variegatus*), flying squirrels (*Ptaurista*, etc.) are the specialized mammal for gliding locomotion. The most of the gliding life inhabits in the middle layer of the forest depending on fruits and young leaves or smaller animals.

Although the most of animal members lives in the high above the ground, it is true that there found special form of animal lives on the forest floor. The scanty light and few primary producer (=plants) are characteristic to the shrub layer and forest floor. Although, there are fewer primary producers, the productivity of the shrub and forest

floor is rather great, because this bottom stratum of the rain-forest receives all the debris that the tree drops; such as corpses, animal faeces, dropped fruits, fallen leaves, broken branches, and fallen down tree truncks. These items form a very rich, decaying litter, which provides favorable habitat and food source for an exotic array of invertebrate and vertebrate fauna. The temperature on the forest floor varies by as little as 5°C throughout the year. Humidity is also constantly in high level around 95% in a day and night. This high humidity and constant temperature enable a number of life which normally regarded as an aquatic form, live to terrestrially in the damp forest.

Among them, there are a multitude of blood-sucking leeches, terrestial Turbellaria (Plate V-E), and crabs scuttle around the ground surface and a great variety of frogs also lives in a hole under roots or in a clump of a wild ginger. Organisms, so called decomposers—termites, pill millipeds, stag beetles, rhinoceros beetles, fungi—are most predominant in this stratum. Many of the shrub dwelling insect employ disguises to protect themselves from predators. They have developed intricated patterns of veins, disease spots and even leafcutter scars to disguise completely.

The mouse deer (*Tragulus*) and the muntjak (*Muntiacus*) are abundant on the forest floor. The Bornean native peoples, Kadasan, have used to call a muntjak by blowing a leaf-whistle, and then, they shoot the doe being enticed into imitating call of a buck. The wild boar (*Sus barbatus*) is most common among the medium-sized mammals in this stratum. The tropical rain-forest which is composed of numerous kinds of trees, always has fruiting trees altering in their breeding season one after the other throughout the year. This seasonless production of fruits provides the most suitable condition for the wild pig living in the world.

Larger mammals, as the orang hutan (*Pongo pygmaeus*), banteng (*Bos banteng*), elephant (*Elephas maximus*), rhinoceros (*Didermocerus sumatrensis*) are becoming rather rare or very scarce in the rain-forst of Sabah, except the elephant. Now, they are under consideration for protection (Fauna Conservation Ordinance of 1963). Especially, the rhinoceros have long been under the powerful hunting pressure of native peoples for bearing a valuable horns, which was believed to have an enormous medicinal and aphrodisiac power by Chinese peoples.

## Records of Survey

The itinerary of our survey trip has been shown in the Table 2.

1. Kinabalu National Park (Fig. 2)

A. Headquaters Area

The Kinabalu National Park, the second lagest national park in Malaysia, lies northeast of Kota Kinabalu, the capital of Sabah. Access to the park headquaters is very easy by the public transportation from Kota Kinabalu. We had the good fortune to accept a kind proposal for suing Land Rover expressed by Sabah Museum, which

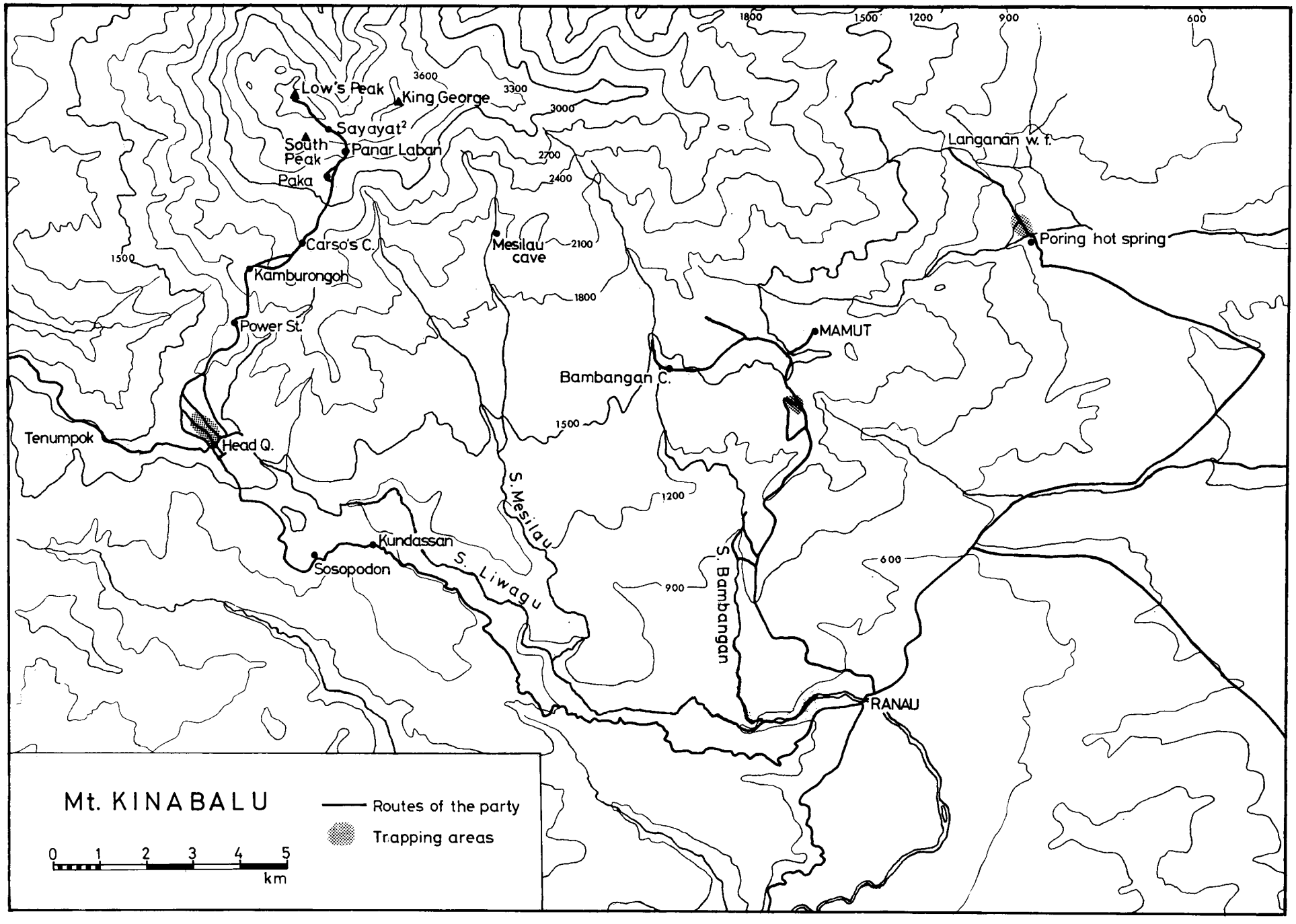


Fig. 2. Kinabalu National Park and neighbouring area. Trapping sites and survey routs are indicated.

Table 2. Summarized record of the survey trip, 1976.

| Date | | Place of sojourn and survey |
|---|---|---|
| Aug. | 5 | Osaka-Hongkong |
| | 6–10 | Kota Kinabalu (stayed in the city for arrangement of survey trip) |
| | 11 | -Kinabalu National Park Headquarters |
| | 12–18 | Mt. Kinabalu* (Park H. Q. area; 13–16, Drs. Yosii and Hotta had tried to access Low's Peak) |
| | 19 | -Poring |
| | 20–22 | Poring Hot Spring* |
| | 23–28 | Ranau and Mamut area* (23–26, Hotta stayed at Bambangan Camp) |
| | 29 | -Telupid |
| | 30–Sept. 3 | Telupid Camp* (Drs. Yosii and Tamura had been despatched to Sandakan on Sept. 1, prior to the party's departure) |
| Sept. | 4 | -Sandakan |
| | 5–8 | Sandakan (making arrangement for journey to southern part of Sabah) |
| | 9–10 | Gomantong Cave* (Gomantong and its associated limestone caves) |
| | 11 | Gomantong-Sandakan |
| | 12–13 | Sandakan |
| | 14 | –Lahad Datu–Kunak |
| | 15–17 | Gunon Madai* (limestone caves) |
| | 18 | Gunon Madai–Lahad Datu |
| | 19 | –Sandakan |
| | 20–22 | Sepilok Forest Reserve* and the Research Center (Hotta stayed in Sepilok until Sept. 26) |
| | 23 | -Kota Kinabalu–Gunong (Mt.) Arab |
| | 24–26 | G. Arab* |
| | 27 | –Kota Kinabalu |
| | 30 | Departed from Kota Kinabalu for Sarawak and Singapore |

* Collecting works had been carried on these areas.

enabled us to travel with our enormous volume of an equipment far up to the National Park Headquaters.

In the area of park headquaters, various routs of a walking path were throughly consolidated. Using this net-work of walking path, the most of our collection had been gathered. Our two botanists had joined with "tree climbers" who had been sent by the Research Center of the Forest Department in Sandakan according to our request.

A junior assitant of Sabah Museum also joined and worked with us throughout the survey trip.

This area had been selected by what the area was expected to maintain typically an altitudinal arrangement of a biological community. This selection might have been profitable to entertain an idea being endowed with fundamental understaning for tropical ecosystem. The duration of our staying at here was also useful to acculimatize our health to tropical climate.

In this area, a vertical distribution of vegetation is clearly appeared by the side of the accessing-road which led us to the Low's Peak (Table 3 and Plate VIII–XIII).

The list of mammals trapped on the environs of the park headquaters is shown in

Table 3. Altitudinal distribution of vegetations on Mt. Kinabalu.

| Locality | Alt. (m) | Warmth index | Characteristics of the vegetation | Vegetation zone |
|---|---|---|---|---|
| Low's Peak | 4,170 | 0 | Rocky alpaine vegetation with circumpolar elements | Alpine zone |
| | 4,000 | 0 | | |
| | | | *Vaccinium-Rhododendron-Leptospermum* scrub | Ericoid scrub |
| Sayat[2] | 3,800 | 12 | | |
| Panar Laban | 3,600 | 24 | *Leptospermum-fflaccinium* forest (2–3 m) on a rocky ridge; *Dacridium* forest (3–4 m) on a mountain slope; *Euphrasia, Potentilla, Gentiana, Ranunculus*, etc. | Ericoid forest and Coniferous forest |
| Paka Cave | 3,200 | 48 | | |
| | | | Leptospermum forest (3–4 m) on a ultrabasic rock area with *Dacridium*; broad leaf evergreen forest (5–7 m) with *Daphniphyllum, Syzygium*, etc. | Edaphic variation of upper montane oak forest |
| Carson's C. | 2,800 | 72 | | |
| | 2,500 | 90 | Oak forest (*Lithocarpus, Quercus*; 10–20m); *Leptospermum* forest on a arid ridge with *Xanthomyrtus* and *Prunus javanicus* | Upper montaine oak forest |
| | 2,100 | 114 | | |
| Power St. | 1,900 | 126 | Mixed oak forest (20 m) without Dipterocarpaceae | Lower montane oak forest |
| | 1,600 | 144 | | |
| | | | Mixed oak forest (20–30 m) with tropical elements (Dipterocarpaceae, Musaceae, Palmae, Araceae, etc.), and *Trigonobalanus, Agathis*. | |
| | 1,000 | 180 | | |
| | | | Hill-type Dipterocarps forest | Tropical rain-forest (Hill-type) |
| Poring | 600 | 209 | | |
| | | | Lowland Dipterocarps forest | Tropical rain-forest (Lowland type) |

the following.

| | |
|---|---|
| *Tupaia montana* | 19 |
| *Dremomys evereti* | 2 |
| *Rattus rattus* | 1 |
| *R. alticola* | 3 |
| *R. sabanus* | 1 |

B. Poring Hot Spring Area

This luxurios health resort for peoples of Sabah offered us a real health resort. Its hot, sulphury water sprung out from the basin of Mamut River and have been channelled into several shallow pools and deep Japanese style baths. The surrounding area have been well-conditioned for a visitor who want to take a walk around or to visit a scenary picturesque of Languanan Waterfall. Poring, locating at the altitude of about 500 m, is exactly the favorable habitat for the leeches. Its high temperature and humidity must be the essential factor for keeping their life, moreover, these areas provide the leafy forest floor and thick litters of fallen leaves, damp soil, fallen-down tree trunks and moist debris of flaky rocks (Plate V-E). They are favored by leeches as a shelter, in which they hide and rest, or a place for "abush", from which they attack preys.

The concentrated dimethylphthalate has a powerful repellent effect for long time (once application on boots or clothes, keeps its contineous effect as long as 3 days).

The trapping record of mammals could not be kept on here. Because all the captures had been picked away by the native peoples residing on neighbouring area.

Among the observed tracks and signs of a mammal, there are shafled foot prints and rooting signs, which had been made by the wild boars in enormous numbers.

C. Mamut Road and Bambangan

These two areas, both situated at the rather high elevation of ca. 1,400 m, are belonged to a lower montane oak forest in confomity with the vegetation zone (Table 3, Plate V-A). Trees are well grown to the height of over 30 m and their expanding branches make a thcik crown layer.

Trapped small mammals are as follows;

| | |
|---|---|
| *Tupaia montana* | 6 |
| *Dremomys evereti* | 1 |

2. Telupid (Fig. 3)

As seen in the Fig. 1, this lowland tropical rain-forest located on the midway of the exclusive cross-cut truckway in the Sabahan interior.

The Dipterocarps forest (lowland forest) is the aboriginally dominant vegetation in Sabah. The tolest tree reaches or exceeds a closed canopy high up to the height of 50–60 m (Plate I-A; Plate IV-A, B, D).

The survey field is in the interior part of the lowland jungle where logging is just carried on. Inside the jungle, growing in tall may have an advantage for being nearer to sunlight. The tall tree which may exceed 60 m is firmly rooted to withstand the

force of the fierce wind. Large, plate-like buttress roots increase the area of a tree's base and improve its stability. There also be found an epiphyte, stag's horn fern and strangling fig growing on the high branches of a tall tree. The latter one develops its hanging root until they can reach the ground and it finally roots itself on the forest

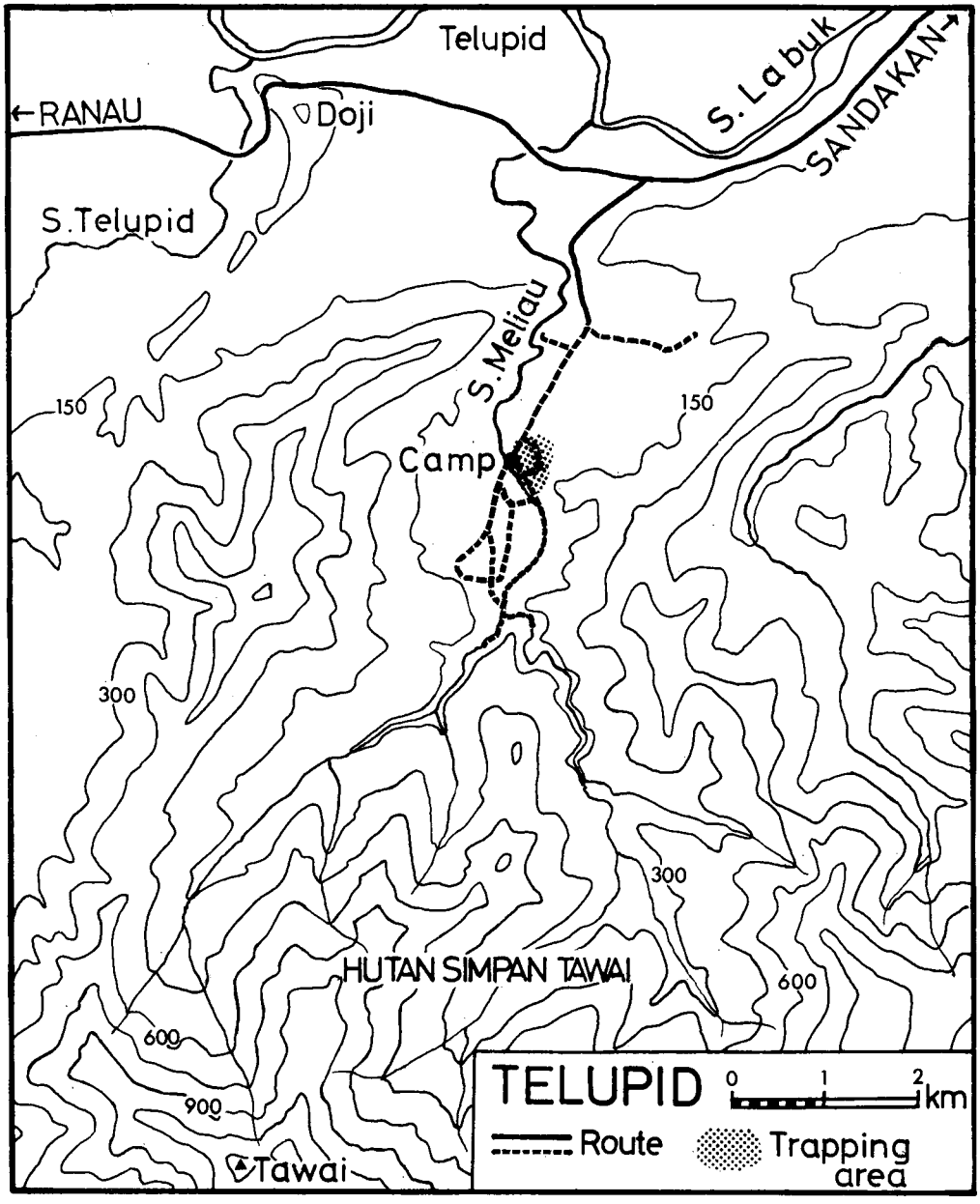


Fig. 3. Detailed map of Telupid camp and surrounding area.

floor. The rooted fig is gradually squeezing the host as it grows, and forced to death. After the host tree decayed, the strangling fig leaves in standing alone.

The property for a logging work on here might be the Diptecroarpacae, because they grow in tall and burly size serving a good character for lumbering.

Small mammals collected here are;

| | |
|---|---|
| *Tupaia glis* | 2 |
| *T. tana* | 1 |

The animals being watched are very rare around here. It might have been resulted from a logging noise, destruction of habitat and atmospheric confusion by human beings who were working in this area. Three primitive primates being listed above, were caught in a deep interior of a jungle separated from the logging site.

3. Limestone Caves on the East Coast

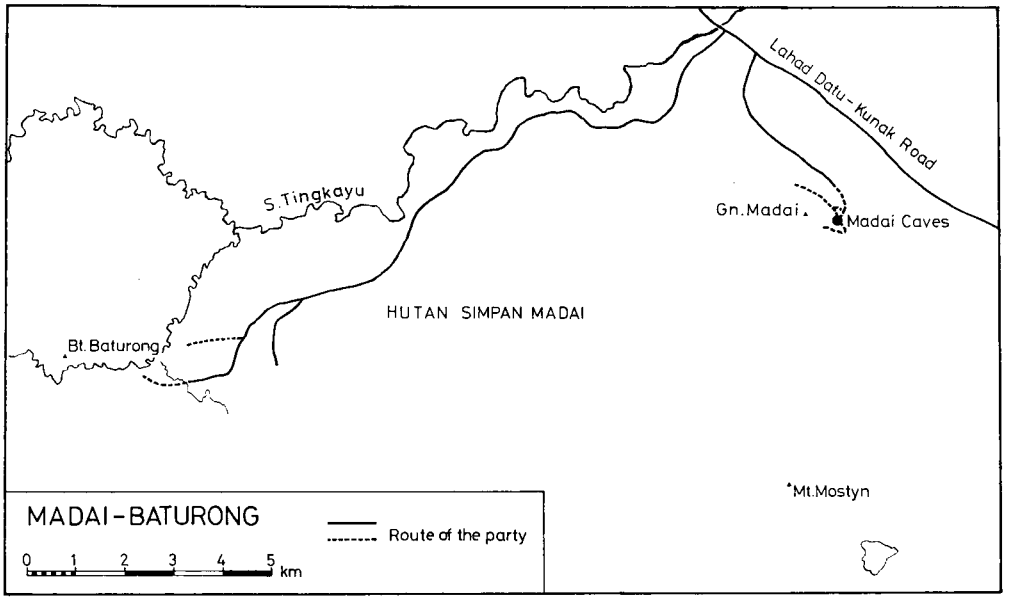


Fig. 4. Sketch map of Gn. Madai and the Tingkayu river-basin.

A. Gomantong Cave

This huge limestone cave situated deeply in the dense jungle which spread on a hill-side, far south from Sandakan Bay (Fig. 1). It might be neccessary to across the bay and ascend the labylinthine water-way of Sg. Swan Lamba (=Swan Lamba River) boading on a small engine-boat beeing assigned by the Forest Department. From the villege of the river-port, Swan Lamba, one must take a continuous long drive of a landrover to the southward interior.

Along the dusty road, there appears tremendous cultivation of an oil-palm and continues towards the interior part. Far south from these plantations, there comes clear sight of a limestone cliff on a foot of a hill. At the front of the limestone cliff, one

can see several cottages associated with a circular open space. A long-house-like cottage was inhabited by a group of a bird-nest collecter, an aborignies. Behind these cottages, there appears a thick jungle which is associated with draughty bamboos growing in clumps.

The famous Gomantong Cave stand inside this dense thicket of rain-forest. Through the giant opening of the cave, we were led to a interior of a huge cathedral, a giant hall being made by a corrosion.

A soft sunlight came down through the sole heaven window which had opened just beneath the hill-top.

Thousands of gregarious swiftlet had made their nests on the inside-wall of the "cathedral" (Plate VII-E) and a numerous number of flying mammals (bats) were hunging on the limestone pendant (Plate VII-C). The thick pile of a guano had heaped up on the stone floor like a damp barnyard manure. They have emitted a offensive smell of anmonium into the air of the attached side-room, where numerous bats roosted during a daytime.

The animals quite other than mammals observed in the interior of the cave are; cockroaches, spiders, ectoparasitic arthropods, etc. (Plate VII-D), all of them might be affiliated with a non-speleans in the meaning of not completely adaptive form to the darkness. The effort for making a collection of mammalian specimens on the Gomantong Cave area, were fully turned to the cave-dwelling chiroptera. The majority of the collection, which is summing up over 150 individuals, is affiliated with suborder Microchiroptera. Several swiftlets (*Collocalia maxima*) were caught with the microchiropteran bat by the same mist-net which were spread across the bat trail in the cave. The bat specimen is now under the consideration of identification, further report will appear in the future.

B. Madai Cave (Fig. 4)

Madai Cave is very similar in the ethnic custom with the Gomantong Cave. The habit for collecting bird-nest by aborigines have been taken over from the prehistoric in Sabah.

The domination for collecting the bird-nest have entirely differed from the Gomantong Cave. The privilage of bird-nest in this cave have been owned by an Islamite, a Malay people. Peoples who want to collect a bird-nest in this cave must ask his permission.

At the front of the cave, there are many collecter's hutts forming a empty village during the party's stay. Collecting season start just after "the Hali Laya days", the new year's festeval of the Moslem. Because the Moslem collecters had been ceasing their work completely during the fasting month of the Islam calendar and returned to their native land leaving their hatts empty.

On the Gunon Madai and its neighbouring area, there appears several limestone outcrops forming hills and cliffs (Plate VII-A). There could be found several cave-mouth in the group or alone, on the same outcrop. In general case, these openings run into

the same excavation and led us to the deeper part of a interior.

The largest and bat-inhabited cave have a interior streamlet which have sprung out at the intermost recess of the cave and run through the master cavern, finally flowed out from the lowest cave-mouth into the surrounding forest. Matters stand in the cave were just similar as that appeared in the Gomantong Cave with several exceptions concerning to the interior flow. The aquatic fauna, small fishes, shrimps, affinitive member of *Macrobrachium*, and several kinds of fresh-water snails. There is no true spelean.

In addition to the subject that the authors had carried on the Gomantong Cave, following matters are investigated.

1. Rudimentary survey of a cave topography.
2. Sampling of several aquatic animals.

The most of botanical samples have been collected here were counted as examples derived from a limestone-dependent flora.

4. Additional Point to the Mountain-Oak Forest

Gunon Arab (=Mt. Arab, Fig. 1)

This mountain is located on the northern part of Crocker Range, that is a mountaineous row on the West Coast and Labuan Residency running from north to south-east direction. A hut of the Museum Sabah is standing below the mountain top. The Tambunan Road from Kota Kinabalu have passed by the front of the hut.

The elevation above sea-level is similar to the National Park Headquaters. The surrounding forest is affiliated with the mountain-oak forest as in the National Park. The climate and topographical conditions are also very similar to the Park Headquaters.

In this area, we could find rich vertebrate fauna and collected some of them.

The list of the small-mammal collection is as follows.

| | |
|---|---|
| *Tupaia montana* | 3 |
| *Calosciurus albescens* | 1 |
| *Sundasciurus jentinki* | 1 |
| *Exilosciurus Whiteheadi* | 1 |
| *Rattus ochraceiventer* | 1 |

In addition to this list, the senior author had trapped one rare specimen, but losed the animal by mishandling. The animal have a good affinity with the "shrew-faced ground squirrel", *Rhinosciurus laticaudatus*. Among its characteristic features, a prolonged muzzule, reduced incisor with a sticky long tongue are conspicuous figures. Inside the surrounding forest, we could seen the numerous foot-print of a mouse-deer.

## Conclusive Notes

The amount of materials that the authors have brought back from the tropical rain-forest in Sabah, easily exceed 15,000 pieces excluding photographs in still and movie, concerned with vegetations and biological communities.

The totaled sum of the collected material is as follows.

| A. Botanical specimen; | No. of pieces |
|---|---|
| 1. Totals preserved in alcohol | 7,000 |
| 2. Seeds | 50 |
| 3. Barks | 50 |
| 4. Woods | 50 |
| 5. Fixed tissues for anatomical study | 100 |
| 6. Raw plant | 300 |
| B. Zoological specimen; | |
| 7. Collembola | 200 sample bottles (over 4,000 individuals) |
| 8. Ectoparasitic arthropoda | 350 sample bottles (over 3,000 indv.) |
| 9. Mammalia | 361 |
| 10. Vertebrata except mammalia | 50 |

The alcoholized botanical specimens have been dried for the use in the herbarium. Taxonomical studies by the junior author is now in advance. Seed samples was sowed as soon as the junior author's returning to his home for raising fresh plant. Raw plant was also planted in the same manner at the Botanical Garden of Osaka City University. Barks and woods are under the consideration for extract their specific components. A brief result of the analytical study on the specific component and the taxonomical findings on the fixed sample have been presented at the Annual Meeting of the Phytotaxonomical Society of Japan and Botanical Society of Japan in 1977.

Brief reports and comprehensive papers on the systematic account will appear in the future.

The second and next step in this project will be turned as follows. In the Botanical interest, the survey area should be altered to the Indonesian Borneo, Celebes, Sunda Is., to collect more informations on the samples from the broader area. For the zoological part, the ecological and more detailed informations will come into needs. So the survey on a greater scale should be taken into their consideration, for the contributor's interest in the next step might be placed in the phylogenetic relationships between the species.

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JAPAN 606

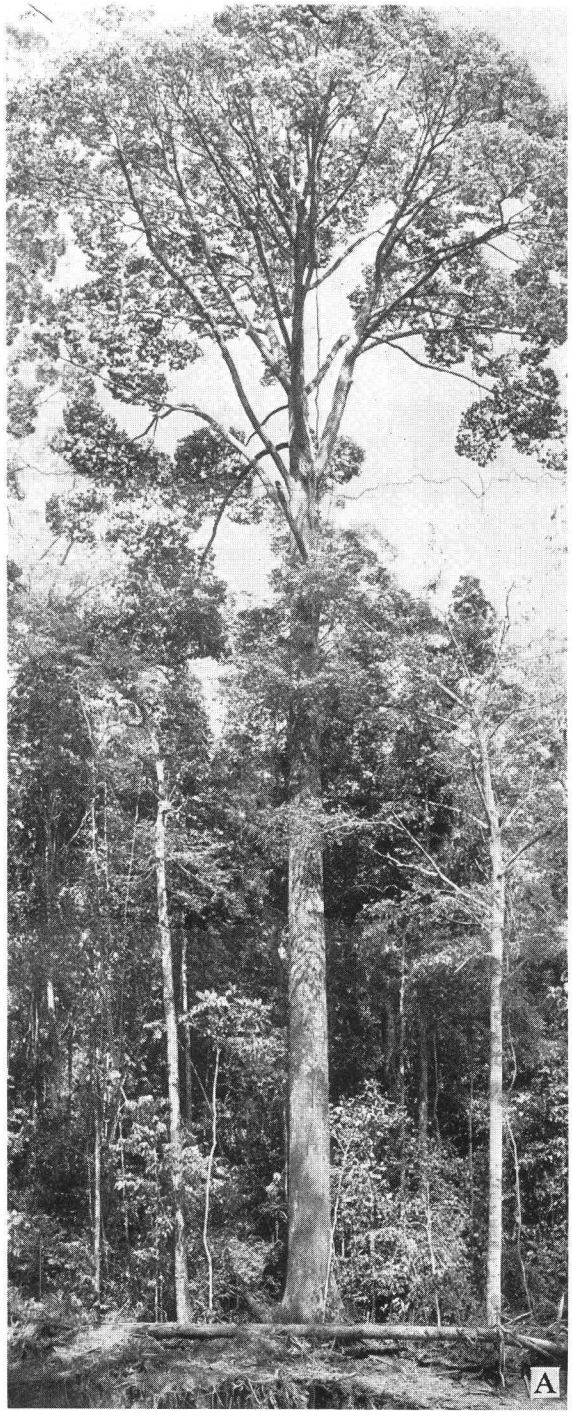
Plate I. Profile of a primary forest (longitudinal sections of a forest shown practically in the same scale).

About 80% of Sabah is covered with various types of the forest. The greater amount of the forest area is still occupied by primary forest in despite of attempts to make shifting cultivations and timber loggings. Three striking types of primary forest can be described as lowland (*Dipterocarpus* and allies), mountain (oak) and subalpine (conifers) forests.

A. Typical Dipterocarps forest. The top of the forest canopy in lowland consists almost of trees of Dipterocarpaceae. They reach to 50–60 m above the ground. The second stratum, usually high above 40 m has rich tree flora of the member of Meliaceae, Moraceae, Myrtaceae, Myristicaceae, etc. The largest tree in the phogotraph is yellow seraya (*Shorea* sp.), about 55 m high. On Telupid, about 160 km west of Sandakan.

B. Lower montane oak forest. The giant tree is *Agathis borneensis* WARB. mixed with large oak trees (*Lithocarpus* spp., *Castanopsis* spp. and *Trigonobalanus verticillata* FORMANN). Small to medium-sized trees are members of Myrtaceae, Myristicaceae, Elaeocarpaceae, Myrcinaceae, Rubiaceae, etc. Forest floor, tree truncks and branches are usually covered by thick moss cushion. Many epiphytes occur in this forest. Near Park Headquarter, Kinabalu National Park, alt. ca. 1500 m.

C. Subalpine coniferous forest dominantly consisted of *Dacridium gibbisiae* STAPF et GIBBS (about 7 m high). Near Paka cave, Kinabalu National Park, alt. 3,300 m.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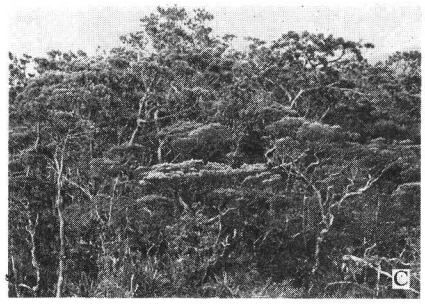
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Plate II. Destruction of the forest.

A. Primary hill Dipterocarps forest and shifting cultivation. Some clearings are reverting to secondary forest. Northern face of Gn. Arab, Crocker Range.

B. Cleared hill-side on which a hill-rice may plant. Near Ranau.

C. Kitchen garden near village. Various kinds of crop appear in mixed cultivatilon: cassava (*Manihot utilissima* POHL), Tannia (*Xanthosoma sagittifolium* SCHOTT), taro (*Colocasia esculenta* L.), sweet potato (*Ipomoea batatas* L.), pineapple (*Ananas comosus* L.), etc. Near Telupid.

D. A variety of hill-rice (dray padi) with dark reddish panicles. Near Ranau.

E. Restructed lowland rain forest by logging. Giant tree with a white bark is mengaris, *Kompassia excelsa* (BECC.) TAUB. Luason, Tawau.

F. Cleared lowland rain forest by fire which might be altered to oil palm plantation. On the road-side between Tawau and Mostyn.


A
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Plate III. Mangrove Forest

Mangrove forest is found along the coast of Beaufort, Labuk, Sandakan, and Tawau. There are maddy coasts which regularly deposited thick silt soil carried by rivers of S. Padas, S. Labuk, S. Kinabatangan and the more small-scaled ones. The main elements of the mangrove forest are representatives of *Rhizophora*, *Sonneratia*, *Avicennia* and *Nipa* palm.

A. Young *Sonneratia* mangrove at low tide. Tanjong Aru, Kota Kinabalu.

B. *Rhizophora* mangrove at high tide. Kuala Sungai Suan Lamba, Sandakan Bay. The forest mostly consist of large trees of *Rhizophora apiculata* Bl., about 15 m high.

C. *Nipa* swamp at low tide, large leaves exceeding 10 m in hight. Near Abai, Kinabatangan.

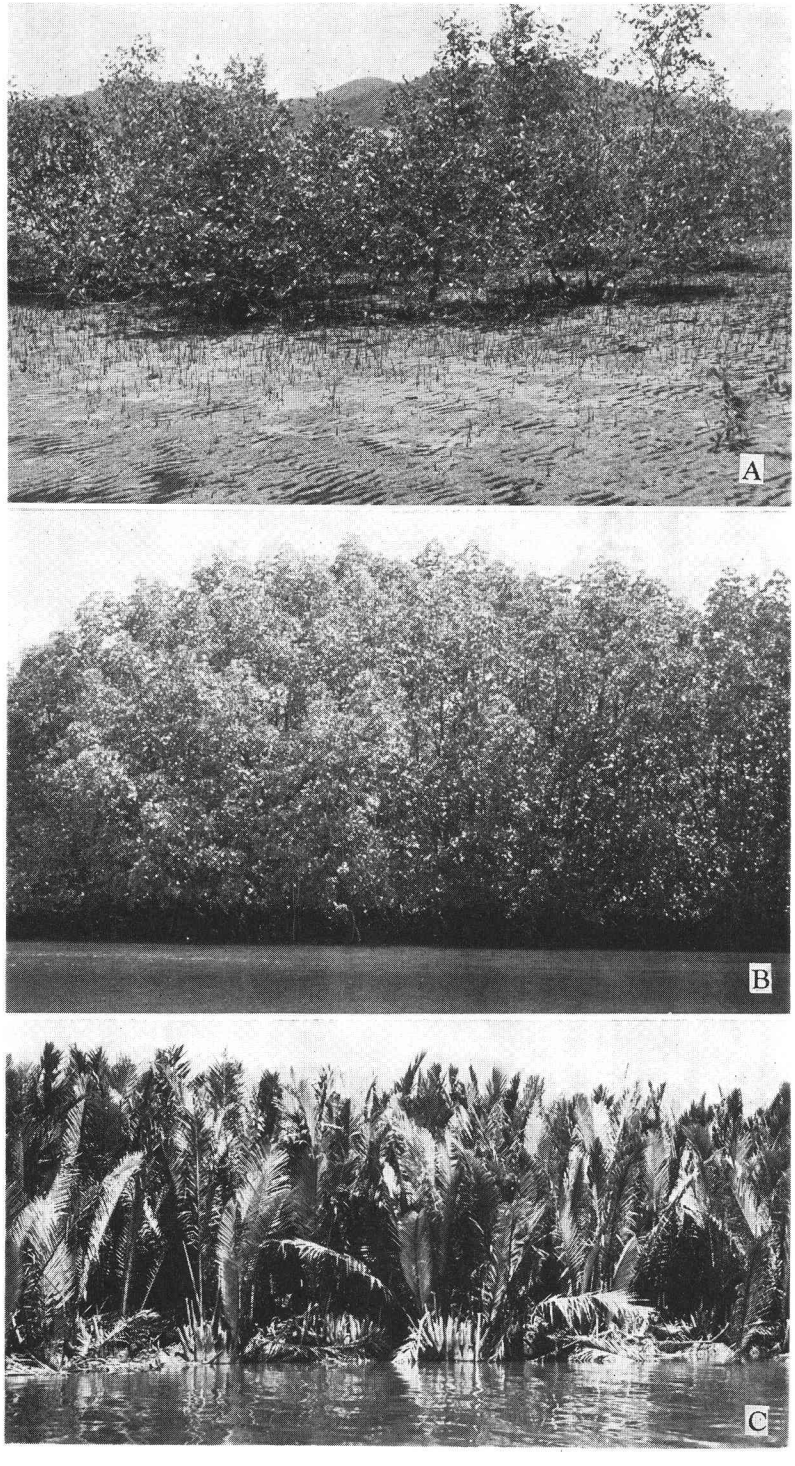
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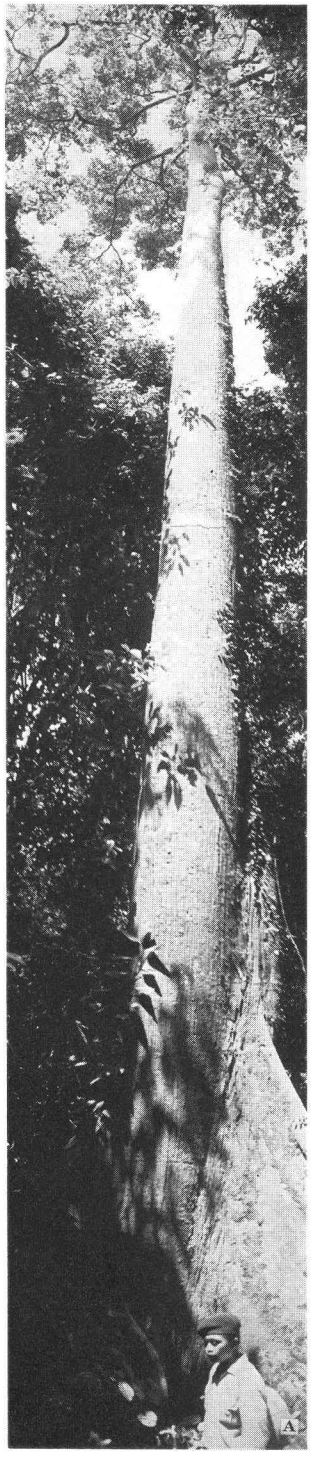
Plate IV. Lowoland forest (Tropical rain-forest or Dipterocarpus forest).

The Dipterocarpus forest is the aboriginally dominant vegetation of a lowland in Sabah. The emergent trees of this forest (up to 50–60 m high) consist chiefly of the species belonged to Dipterocarpaceae, which occurs up to 1,000–1,600 m by altitude. The forest has the richest tree flora in tropics and closed canopy with multistratal layers.

A. Large yellow seraya (*Shorea* sp., sect. Ricnetia), about 60 m in hight. Kinabatangan.
B. The base of a yellow seraya, with large buttresses. Kinabatangan.
C. Riparian forest along Sungai Maila, Telupid.
D. Aerial view of the tropical rain-forest. Sandakan—Lahad Datu.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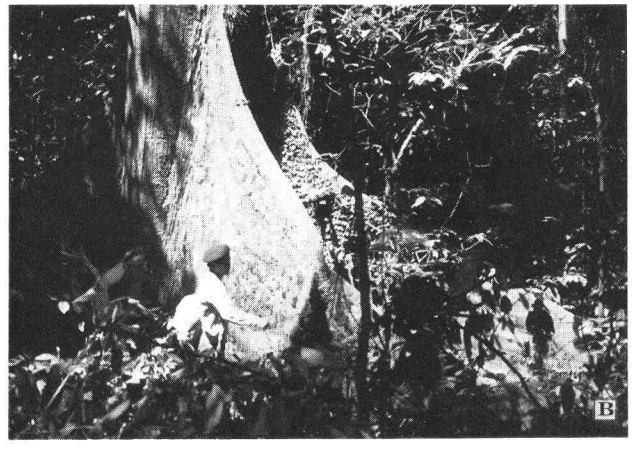
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Plate V. Plants of lowland.

A. Giant bamboo, *Dendrocalamus asper* BACKER, grows in clumps, high up to 31 m. Suburbs of the Poring Hot Spring, Kinabalu National Park.
B. A giant aroid, *Alocasia robusta* M. HOTTA, standing by the open place on the river side. Madai Cave.
C. *Dillenia excelsa* (JACK.) GILG. with a pale yellow flower. On the roadside to Telupid.
D. Inflorescence of *Dillenia beccariana* MART. with young fruits and floral buds. Mt. Lucia, Tawau.
E. The common leech is one of "the most familiar" animal for the visitor. Poring Hot Spring.


A


B


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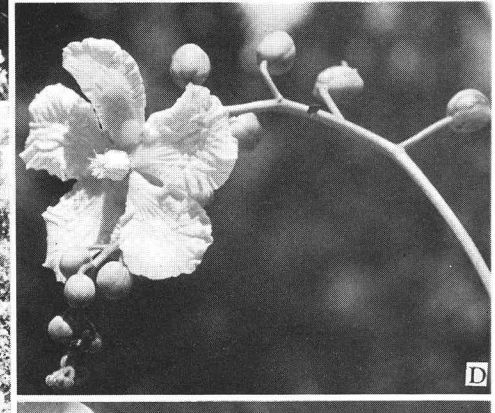
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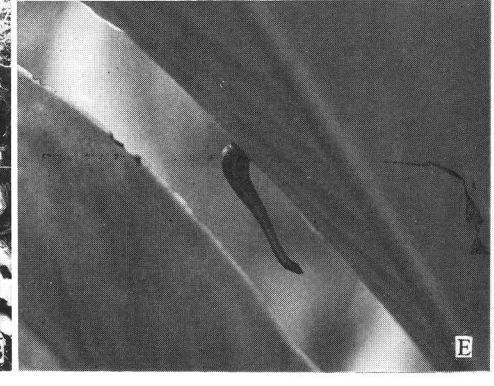
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Plate VI. Animal life in the tropical rain-forest.

A. A mountain spiny-rat, *Rattus alticola.* Trapped in the montane oak forest appeared along the streamlet of the Liwagu Trail, near the Park Headquaters, Kinabalu National Park.

B. Common tree-shrew, *Tupaia glis*, captured in the forest of Telupid. The most beautiful species in Tupaiidae. The color is dark brown with brilliant reddish hair in dorsum, reddish buff in venter.

C. Venomous green snake, *Trimeresurus wagleri*, appears in a forest. Telupid.


A
B
C

Plate VII. Limestone caves on the eastern coast.

A. Limestone cliff of Gn. Madai. The Madai Cave opens its mouth at the foot of the cliff. Bird-nest collecter's huts is seen in front of the Cave.
B. One of the allied caves on Gn. Madai. View from the interior through the cave-mouth showing the comparable size to a man standing in front of the mouth.
C. Hangging bat on the side-wall of the interior. White arrow shows hangging individuals.
D. Heaped bat-guano on the cave-floor. Arrow shows a wriggling cocrooch.
E. Swiftlets roost on the side-wall of the cave.
F. Package-works for bird-nest are going on by aborigines. The bird-nest contains abundant impurities as feathers (looking blackish materials) to the pure whitish dry-saliva.

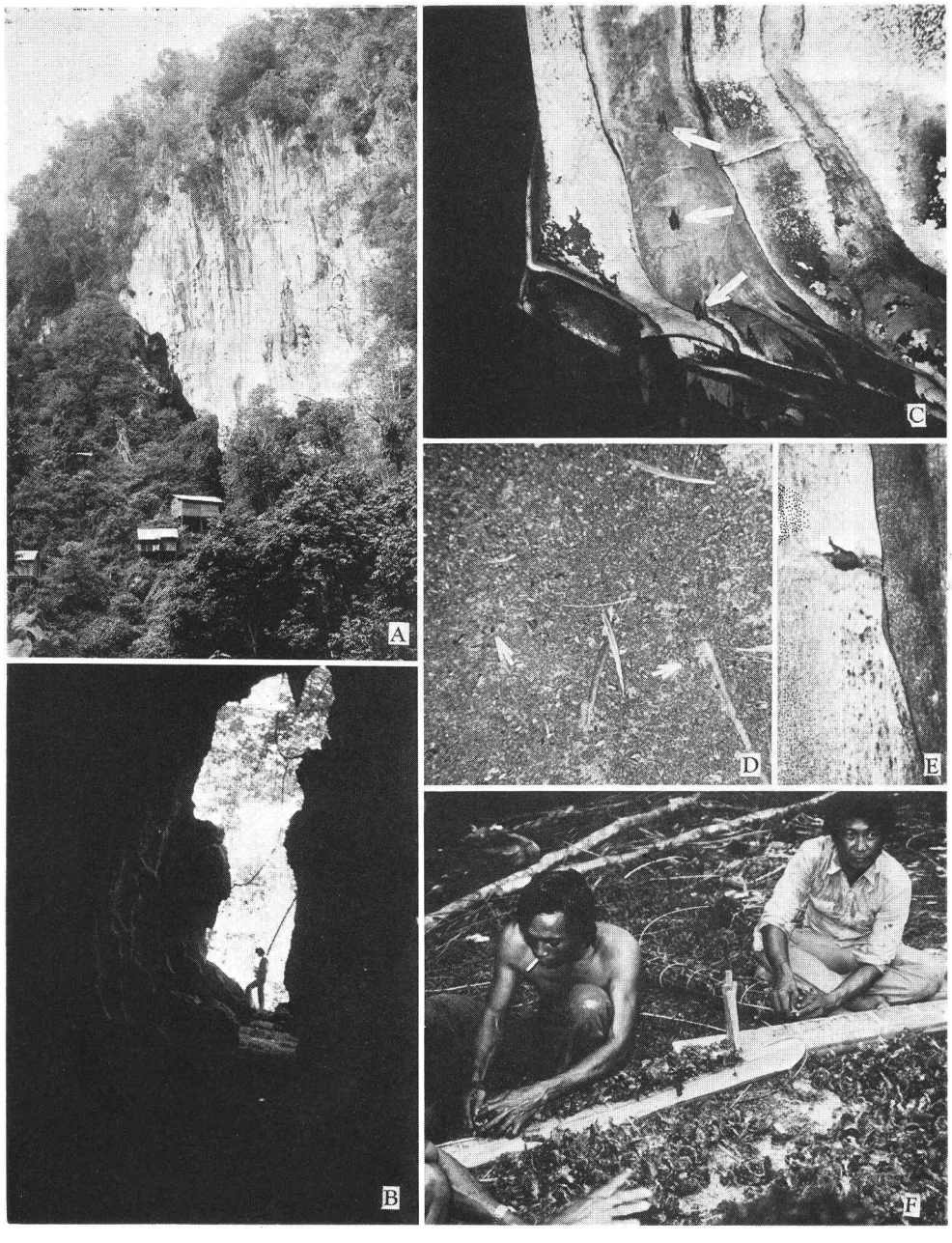
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Plate VIII. Montane Oak Forest.

The montane oak forest above 1,000 m has a poor relation to lowland forest. The canopy is lower than the lowland forest with three or four strata. Dominant tree species are evergreen broad leaf oak (*Lithocarpus*, *Quercus* and *Trigonobalanus*) with representatives of certain families; Symplocaceae, Theaceae, Magnoliaceae, Elaeocarpaceae, Podocarpaceae, etc. Above 1600 m many lowland elements such as Dipterocarpaceae, Palmae, Araceae, Musaceae, etc. are disappeared. There is a rise of moss growth, epiphytes, tree ferns and herbs with temperate affinity (*Viola*, *Carex*, *Galium*, etc.).

A. Montane oak forest, Mamut ridge (1,500 m). This forest has large trees of *Lithocarpus* spp. and *Agathis borneensis* WARB. with *Trigonobalanus verticillata* FORMAN and *Podocarpus imbricatus* BL.

B. Inside of mountain oak forest. Gn. Arab (ca. 2,000 m).

C. *Lithocarpus turbinatus* (STAPF) FORMAN with a large fruit covered by cupule. Near Kambalongoh (ca. 2,000 m), Mt. Kinabalu.

D. *Trigonobalanus verticillata* FORMAN with many coppices. Mamut ridge (ca. 1,600 m), Mt. Kinabalu.


A
B
C
D

Plate IX. Plants of the Montane Oak Forest.

A. *Impatiens platypetala* LINDL. with conspicuous pink flowers. G. Arab (2,200 m).
B. A highland form of *Pipthospatha havilandii* ENGLER. S. Liwagu (ca. 1,400 m), Mt. Kinabalu.
C. *Hedychium cylindricum* RIDLEY, a ginger with white flowers. Near the Park Headquarters (1,600 m), Mt. Kinabalu.
D. *Viola serpens* WALL., a small violet on the forest floor. Gn. Arab (2,000).


A
B
C
D

Plate X. *Rhododendron* of Mt. Kinabalu.

A. *Rhododendron lowii* Hook. f., inflorescence nearly 35 cm in diameter with large yellow flowers. Kambarongoh to Carson's Camp (2,600 m).

B. *Rhododendron buxifolium* Low ex Hook. f., characterized by small, thick leaves and crimson-red flowers. Near Sayat Sayat (ca, 3,600 m).

C. *Rhododendron stenophyllum* Hook. f. ex Becc., a unique endemic species of Mt. Kinabalu. Mamut ridge (ca. 1,800 m).

D. A epiphytic *Rhododendron* with long floral tubes. Near the Park Headquarters (ca. 1,500 m).


A
B
C
D

Plate XI. Vegetation on an ultrabasic rock of the western Kinabalu.

Just above the Carson's Camp (ca. 2,700 m), vegetation is suddenly changed to *Leptospermum-Dacrydium* semi-open forest with ground herbs of *Cladium falcatum* C. B. CLARKE, *Nepenthes villosa* HOOK. f., *Aletris foliolosa* STAPF, etc.

A. *Leptospermum* forest, 4 m high. Above Carson's Camp (2,750 m).

B. *Dacrydium* forest and the western face of South Peak. From ca. 3,000 m altitude.

C. *Nepenthes villosa* HOOK. f., near Carson's Camp (2,800 m).

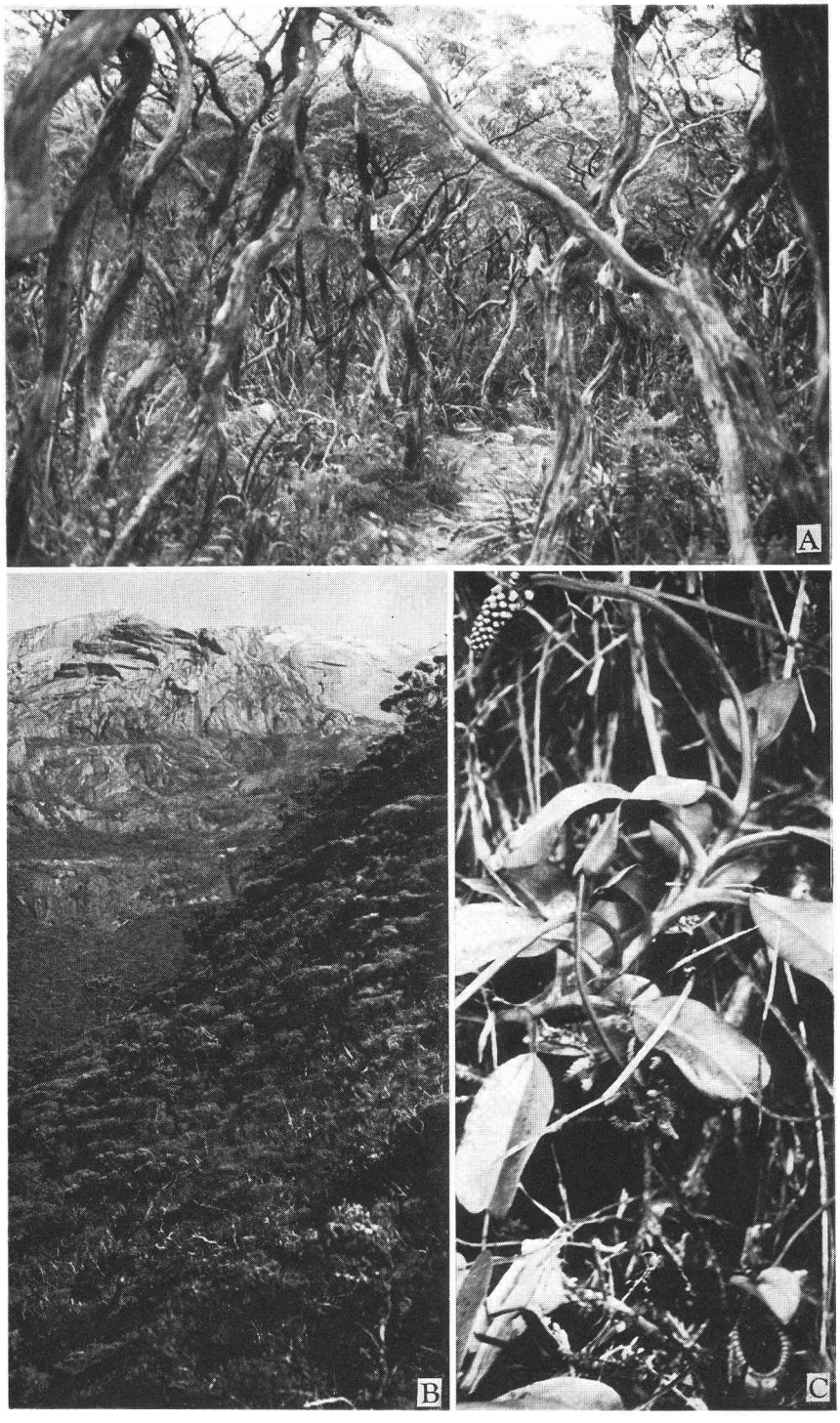
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Plate XII. Ericoid forest and scrub on Mt. Kinabalu.

A. *Vaccinium-Leptospermum* ericoid forest about 3 m high. On the ridge near Paka Cave (3,200 m).
B. *Talauma* sp., rigid-leaved *Talauma*, a representative of new species. Paka Cave (3,200 m).
C. A alpine form of *Drimys piperita* HOOK. f. Near Sayat Sayat (3,700 m).
D. Flowering of *Leptospermum* sp., alpine small tree with large white flowers. Near Panar Laban (3,300 m).
E. *Euphrasia borneensis* HOOK. f., with white flowers. Near Panar Laban (3,300 m).
F. *Schima brevifolia* (HOOK. f.) STAPF, scrub with large white flower. Near Sayat Sayat (3,700 m).


A
B
C
D
E
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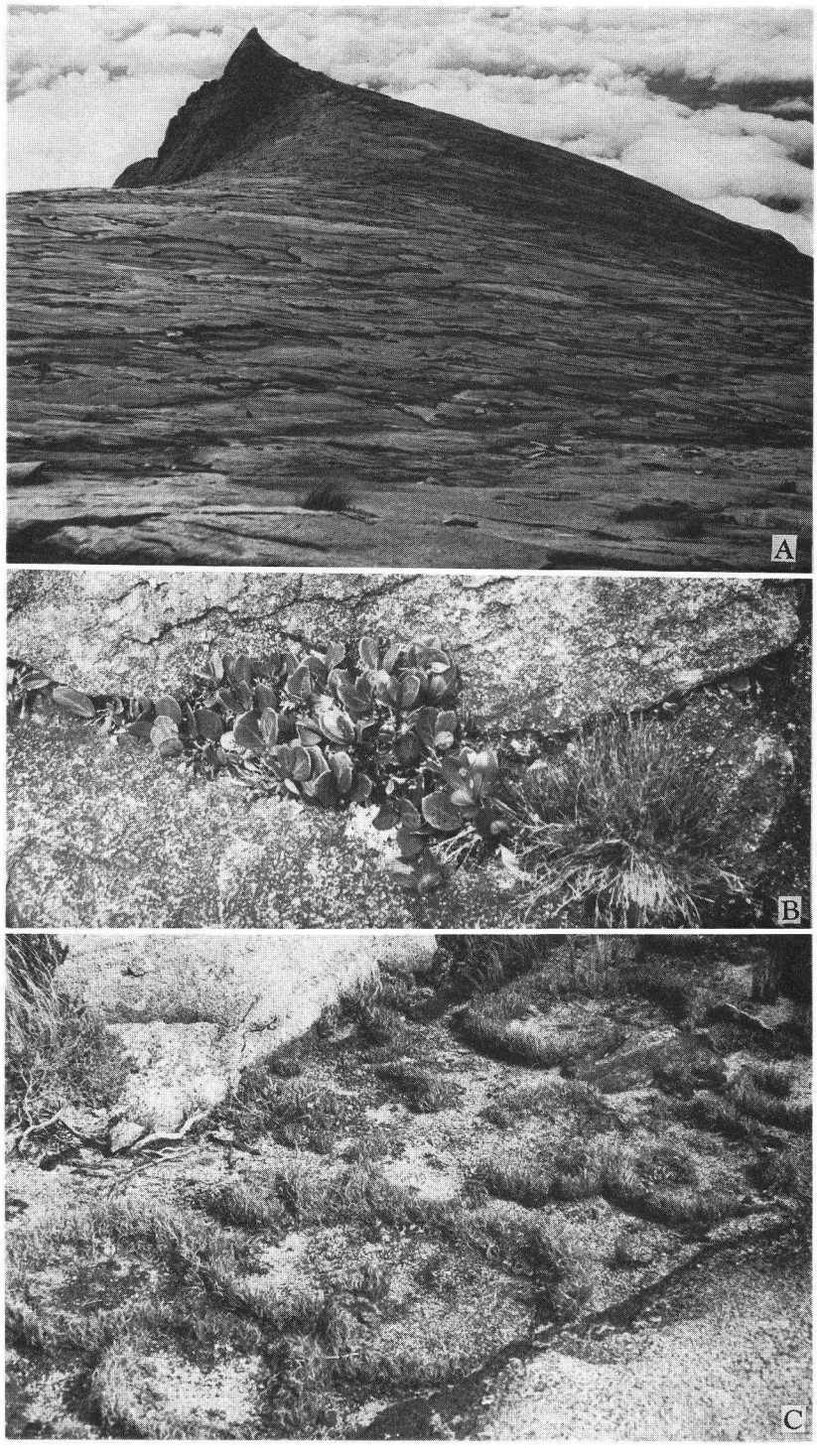
Plate XIII. Alpine zone of Mt. Kinabalu.

A. South Peak and flat granite plateau, poor patches of grass at cracks. From foot of Low's Peak (3,900 m).
B. A small patch of *Vaccinium* low scrub in crack of granite rock. Near South Peak (3,800 m).
C. Ring like growth of *Eleocharis* on sandy soil (3,800 m).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